

YIELD AND BIOMASS QUALITY OF THE WHOLE PLANT OF FOUR MAIZE HYBRIDS FOR SILAGE PRODUCTION

PRINOS I KVALITET BIOMASE CELE BILJKE ČETIRI HIBRIDA KUKURUZA ZA PROIZVODNJU SILAŽE

Dušanka TERZIĆ*, Milica RADOSAVLJEVIĆ*, Marija MILAŠINOVIĆ-ŠEREMEŠIĆ**, Života JOVANOVIĆ*, Valentina NIKOLIĆ*
*Maize Research Institute, Zemun Polje, Slobodana Bajića 1, Belgrade, Serbia
**Institute of Food Technology in Novi Sad, Bulevar cara Lazara 1, Novi Sad, Serbia
e-mail: rnilica@mrizp.rs

ABSTRACT

This paper presents the results of a study on the yields of green matter, dry matter and digestible dry matter of the whole plant of four ZP silage maize hybrids (grown in four different locations in the Republic of Serbia) and the quality of their whole-plant biomass. The results obtained indicate that the highest average yields of green matter ($40.4 \text{ t}\cdot\text{ha}^{-1}$), dry matter ($14.4 \text{ t}\cdot\text{ha}^{-1}$) and digestible dry matter of the whole plant ($8.8 \text{ t}\cdot\text{ha}^{-1}$) were recorded in the ZP 707 hybrid at all four locations considered. The highest average content of lignocellulosic fibres was detected in the ZP 735 hybrid, which also exhibited the lowest dry matter digestibility of the whole plant (57.24%). The highest average digestibility of dry matter (61.00%) and NDF (NDFD - Neutral Detergent Fibres Digestibility) (26.20%) of the whole maize plant was determined in the ZP 707 hybrid, which also had the lowest average content of all lignocellulosic fibres.

Key words: maize, yield, biomass quality.

REZIME

Kukuruz je najvažnija krmna biljka po visini prinosa i kvalitetu biomase. Najvažniji parametri kvaliteta silažnih formi hibrida kukuruza su: prinos ukupne i svarljive suve materije, sadržaj i odnosi lignoceluloznih vlakana (NDF – vlakna nerastvorna u neutralnom deterdžentu, ADF – vlakna nerastvorna u kiselom deterdžentu i ADL – lignin nerastvorljiv u 72% rastvoru sumporne kiseline), svarljivost suve materije i svarljivost NDF (NDFD) cele biljke kukuruza. Svarljivost suve materije i NDFD daju preciznije podatke o kvalitetu biomase kukuruzne biljke za silažu.

U ovom radu su prikazani rezultati istraživanja prinosa zelene mase, suve materije i svarljive suve materije, kao i kvaliteta biomase (sadržaj i odnosi lignoceluloznih vlakana, svarljivost suve materije i NDF) cele biljke četiri silažna ZP hibrida kukuruza gajenih na četiri različite lokacije u Republici Srbiji. Rezultati su pokazali da se prosečan sadržaj suve materije cele biljke kretao od 28,03% (ZP 735) do 35,84% (ZP 707). Najviši prosečan prinos zelene mase od $40,4 \text{ t}\cdot\text{ha}^{-1}$, suve materije od $14,4 \text{ t}\cdot\text{ha}^{-1}$ i prinos svarljive suve materije cele kukuruzne biljke za sve četiri lokacija od $8,8 \text{ t}\cdot\text{ha}^{-1}$ imao je hibrid ZP 707. Najviši prosečan sadržaj lignoceluloznih vlakana (NDF, ADF, hemiceluloze i celuloze) imao je hibrid ZP 735 koji je imao najnižu svarljivost suve materije cele kukuruzne biljke (57,24%). Najvišu prosečnu svarljivost suve materije (61,00%) i NDFD (26,20%) cele kukuruzne biljke imao je hibrid ZP 707 koji je imao i najniži prosečan sadržaj svih lignoceluloznih vlakana: NDF (52,85%), ADF (26,11%), ADL (3,31%), hemiceluloze (26,74%) i celuloze (22,80%).

Cljučne reči: kukuruz, prinos, kvalitet biomase.

INTRODUCTION

Maize is the most important forage crop according to its yield, biomass quality, diversity of use in animal nutrition, and suitability for silage (Bekrić, 1997). The yield of silage maize depends on its genetic yield potential and the agroecological conditions of its production. The development of new silage maize hybrids has been gaining increasing importance in both Serbia and worldwide (Pejić, 1994; Coors and Lauer, 2001, Milašinović-Šeremešić et al., 2017). The following parameters are considered most important for the quality of silage maize hybrids: yields of the total and digestible organic matter, contents and ratios of lignocelluloses fibres (namely neutral detergent fibres composed of hemicelluloses, cellulose and lignin (NDF), acid detergent fibres composed of cellulose and lignin (ADF), and acid detergent lignin (ADL)), and the digestibility of dry matter and neutral detergent fibres (NDF) of the whole maize plant. The quality of maize biomass is very important for the evaluation of silage maize, inbred selection, breeding and the development of new silage hybrids (Terzić et al., 2014; Radosavljević et al., 2015).

The purpose of this paper is to determine the yield and biomass quality (namely the content and ratios of lignocellulosic fibres, dry matter digestibility and NDF) of the whole plant of four silage maize hybrids grown in four different locations in Serbia.

MATERIAL AND METHOD

Four ZP maize hybrids of the FAO maturity group 700-800 (ZP 707, ZP 735, ZP 873, and ZP 7357) were enrolled in the study. The hybrids were grown in four different locations in the Republic of Serbia (Valjevska Loznica, Donja Trepča, Prnjavor and Bačinci) in 2019. The sowing density ranged from 52,000 to 62,000 plants per hectare. After harvest at the full waxy maturity stage, samples of the whole plants of the maize hybrids considered were dried and ground in a mill with 1-mm mesh sieves. The samples were subsequently analysed to determine their contents of absolutely dry matter and lignocelluloses fibres (NDF, ADF and ADL, hemicelluloses and cellulose) using the modified Van Soest detergent method (Mertens, 1992). Moreover, the *in vitro* digestibility of the samples was determined using the Aufréré method (Aufréré, 2006).

RESULTS AND DISCUSSION

Table 1 shows the average content of grain moisture and dry matter of the whole plant of the maize hybrids considered and their average yields of green matter, dry matter and digestible dry matter.

Table 1. The average content of grain moisture and dry matter of the whole plant of the maize hybrids grown in four locations in Serbia (Valjevska Loznica, Donja Trepča, Prnjavor and Bačinci) and their yields of green matter, dry matter and digestible dry matter

Hybrid	Grain moisture (%)	Whole plant			
		Dry matter content (%)	Green matter yield (t ha ⁻¹)	Dry matter yield (t ha ⁻¹)	Digestible dry matter yield (t ha ⁻¹)
ZP 707	30.55	35.84	40.4	14.4	8.8
ZP 735	36.88	28.03	36.3	10.2	5.9
ZP 873	34.10	32.09	37.8	12.0	7.1
ZP 7357	34.48	33.57	37.4	12.4	7.2
Average	34.00	32.38	38.0	12.2	7.2
SD	2.61	3.29	1.7	1.7	1.2

SD – standard deviation

The following results were obtained for the maize hybrids considered: the contents of grain moisture ranged from 30.55 % (ZP 707) to 36.88 % (ZP 735), the contents of dry matter of the whole plant ranged from 28.03 % (ZP 735) to 35.84 % (ZP 707), the yields of green matter and dry matter ranged from 36.3 t ha⁻¹ (ZP 735) to 40.4 t ha⁻¹ (ZP 707) and from 10.2 t ha⁻¹ (ZP 735) to 14.4 t ha⁻¹ (ZP 707), and the yields of digestible dry matter ranged from 5.9 (ZP 735) to 8.8 t ha⁻¹ (ZP 707) (Table 1). The ZP 707 hybrid was found to have the highest average yields of green matter, dry matter and digestible dry matter of the whole plant in all four locations considered (40.4 t ha⁻¹, 14.4 t ha⁻¹ and 8.8 t ha⁻¹, respectively). Conversely, the lowest average yields of green matter, dry matter and digestible dry matter of the whole plant were recorded in the ZP 735 hybrid, i.e. 36.3 t ha⁻¹, 10.2 t ha⁻¹ and 5.9 t ha⁻¹, respectively.

The content of lignocellulosic fibres (NDF, ADF, ADL, hemicellulose and cellulose) is one of the most important parameters of biomass quality and nutritive value of maize plants used in ruminant nutrition. The following average NDF, ADF, ADL, hemicelluloses and cellulose contents of the whole plant of the maize hybrids considered were recorded: NDF ranged from 52.8 % (ZP 707) to 56.40 % (ZP 735), ADF ranged from 26.11 % (ZP 707) to 28.20 % (ZP 735), ADL ranged from 3.31 % (ZP 707) to 3.74 % (ZP 7357), hemicelluloses ranged from 26.74 % (ZP 707) to 28.20 % (ZP 735) and cellulose ranged from 22.80 % (ZP 707) to 24.53 %

Table 2. Average contents of lignocellulosic fibres of the whole plants of the maize hybrids grown in Valjevska Loznica, Donja Trepča, Prnjavor and Bačinci

Hybrid	Content (%)				
	NDF	ADF	ADL	Hemicellulose	Cellul.
ZP 707	52.85	26.11	3.31	26.74	22.80
ZP 735	56.40	28.20	3.68	28.20	24.53
ZP 873	54.33	26.90	3.34	27.43	23.57
ZP 7357	55.29	27.98	3.74	27.32	24.24
Average	54.72	27.30	3.52	27.42	23.78
SD	1.51	0.98	0.22	0.60	0.77

NDF – neutral detergent fibres, ADF – acid detergent fibres and ADL – acid detergent lignin

(ZP 735) (Table 2). The following average ratios of lignocellulosic fibres of the whole plant of the maize hybrids considered were recorded: L/NDF ranged from 6.14 % (ZP 873) to 6.76 % (ZP 7357), L/ADF ranged from 12.41 % (ZP 873) to 13.36 % (ZP 7357), ADF/NDF ranged from 49.40 % (ZP 707) to 50.59 % (ZP 7357), Hcell/NDF ranged from 49.41 % (ZP 7357) to 50.60 % (ZP 707), Cell/NDF ranged from 43.14 % (ZP 707) to 43.84 % (ZP 7357), and Cell/Hcell ranged from 85.25 % (ZP 707) to 88.73 % (ZP 7357) (Table 3). The ZP 707 and ZP 873 hybrids were found to have the lowest average ratios of L/NDF, L/ADF, ADF/NDF and Cell/NDF and the highest average dry matter digestibility and NDFD (Table 3 and Figure 1). The results obtained in the present study are consistent with the results reported in the literature (Khan et al., 2015; Semenčenko et al., 2016). A number of recent studies have focused on determining the dry matter digestibility and NDF of maize plants in order to produce highly valuable maize biomass for high-quality silage (Milašinović-Šeremešić et al., 2017; Comert Acar et al., 2018)). The following equation was used to calculate the digestible NDF (NDFD) of the maize hybrids considered relative to their total NDF: NDFD = 100 (ES - (100-NDF)) / NDF (Brenner et al., 2010). The average digestibility of dry matter and NDFD of the whole plant of the maize hybrids

considered ranged from 57.24 (ZP 735) to 61.00% (ZP 707) and from 23.81 (ZP 7357) to 26.20% (ZP 707), respectively (Figure 1). The results obtained are consistent with the results of Barriere et al., 2009; Bertoia et al., 2014; Ferreira et al., 2014; Terzić et al., 2014; Milašinović-Šeremešić et al., 2017).

Table 3. Average ratios of lignocellulosic fibres of the whole plant of the maize hybrids grown in Valjevska Loznica, Donja Trepča, Prnjavor and Bačinci

Hybrid	Ratio (%)					
	L/ NDF	L/ ADF	ADF/ NDF	Hcell/ NDF	Cell/ NDF	Cell/ Hcell
ZP 707	6.26	12.68	49.40	50.60	43.14	85.25
ZP 735	6.52	13.03	50.00	50.00	43.49	86.98
ZP 873	6.14	12.41	49.51	50.49	43.37	85.91
ZP 7357	6.76	13.36	50.59	49.41	43.84	88.73
Average	6.42	12.87	49.88	50.12	43.46	86.71
SD	0.27	0.42	0.54	0.54	0.29	1.52

Hcell – hemicellulose, Cell - cellulose

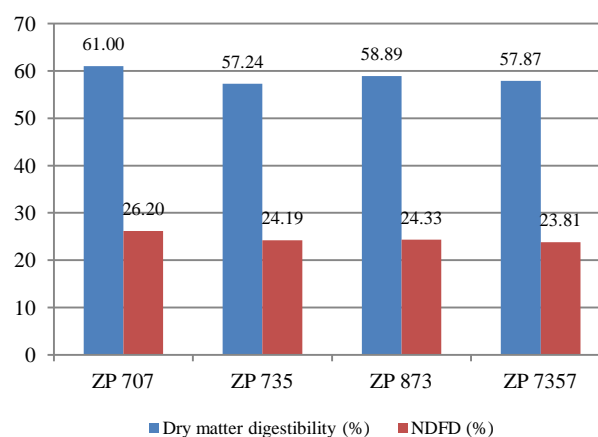


Figure 1. Average dry matter digestibility and NDFD (digestible NDF) of the whole plant of the maize hybrids grown in Valjevska Loznica, Donja Trepča, Prnjavor and Bačinci

CONCLUSION

The ZP 707 maize hybrid was found to have the highest yields of green matter, dry matter and digestible dry matter of the whole plant (40.4 t ha⁻¹, 14.4 t ha⁻¹ and 8.8 t ha⁻¹, respectively) at all four locations considered. However, the lowest yields of green matter, dry matter and digestible dry matter of the whole plant (36.3 t ha⁻¹, 10.2 t ha⁻¹ and 5.9 t ha⁻¹, respectively) were established in the ZP 735 hybrid.

The highest average content of lignocellulosic fibres (NDF, ADF, hemicelluloses and cellulose) was detected in the ZP 735 hybrid, as well as the lowest average digestibility of dry matter of the whole maize plant (57.24%). The highest average dry matter digestibility (61.00%) and NDFD (26.20%) of the whole maize plant were detected in the ZP 707 hybrid, as well as the lowest content of all lignocellulosic fibres: NDF (52.85%), ADF (26.11%), ADL (3.31%), hemicellulose (26.74%) and cellulose (22.80%). The lowest ratios of L/NDF, L/ADF, ADF/NDF, Cell/NDF were established in the ZP 707 and ZP 873 hybrids.

The ZP 707 hybrid was found to have the highest average yields of green matter, dry matter and digestible dry matter, as well as the lowest average content of all lignocellulosic fibres and the highest average digestibility of dry matter and NDFD.

ACKNOWLEDGMENT: This paper is a result of Project 31068 (*The Improvement of Properties of Maize and Soya Bean by Molecular and Conventional Breeding*), funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

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Received: 18.02.2020.

Accepted: 30.04.2020.